Evolutionary Explanations in Medicine

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In 1974 the Noble Prize Committee awarded Tinbergen, Von Frisch, and Lorenz, three evolutionary biologists working on animal behaviour, the Noble prized for "Physiology and Medicine". Explanations for the committee's unusual choice abound, but perhaps it is best to think that the Noble committee, in its wisdom, realized that evolutionary principles could be applied to medicine, and tried to give an impetus to this process. Change was slow, but a quarter of a century later we started to see the development of a new field of study: "evolutionary medicine".

Progress might have been slow simply because evolutionary explanations different from the types of explanations more familiar in medicine. One of Tinbergen's most important contributions was a framework he proposed for studying any biological phenomena. Tinbergen pointed out that study and understanding can occur at 4 levels: (1) Ontogeny: how does it develop within an individual? (2) Causation: what causes it? Internally and externally, from the molecular or the organismic level, (3) Function: what is its current or past survival value (short-term consequences)? What is its adaptive significance (ultimate consequences)? And (4) Evolution: how did it evolve in the population or the species, related species and ancestral forms? These approaches are complementary, not mutually exclusive, and different people, depending on their backgrounds and interests, will be inclined to answer the same question in different ways.

Let us take a simple example: obesity. (1) Ontogeny: a developmental biologist might be inclined to ask about the factors during foetal growth or childhood, such as key events or habits that increase the likelihood of the adult condition. (2) Causation: a molecular geneticist might try to identify specific genes associated with the condition. A physiologist would might try to uncover the neurotransmitters or hormones associated with the condition. A behaviourist might try to identify environmental and social factors that worsen the condition. (3) Function: a behaviourist al ecologist might examine the social causes for and consequences of the condition. An evolutionary biologist would focus on selective forces, in the present or the past, that made the condition beneficial, or try to uncover additional effects of the main genes responsible (4) Evolution: a population geneticist might be interested in the heritability of the condition, or compare the frequency of particular genes in different populations, or even perhaps related species. None of these approaches is incorrect; none is better than the rest. They are just different ways of looking at the same problem. Note that I purposely left my explanations vague enough so they could be applied to any medical condition: emphysema, pre-eclampsia, schizophrenia, Hodgkin's lymphoma, iron deficiency, schistosomiasis, etc. Full understanding requires examining the problem from all angles.

The first two types of explanations, ontogeny and causation, are referred to as the "proximate" approach, and the latter two, function and evolution, as the "ultimate" approach. One difference between these approaches is the degree of urgency associated with them. Proximate explanations address cause-and-effect relationships here and now, their timing ranging from a few seconds to, at the most, an individual's lifetime. In contrast, ultimate explanations take into account other factors, such as ancestry, population genetics, evolutionary history and ecology. Medicine is usually concerned with relieving suffering, so it tends to favour the proximate approach. The second major difference between ultimate and proximate explanations: evolutionary explanations generally deal with populations, not individuals. Evolutionary explanations cannot explain why any one individual develops a disease or suggest treatments for any one individual. Evolutionary thinking in medicine overlaps with epidemiology, the study of disease in populations. Therefore, when studying populations, the sense of urgency needed to help an individual is replaced by a greater degree of importance to potentially help an entire population.

Evolutionary biologists are not too concerned about how things occur, but are more interested on why they happen to occur that way, and not another. They tend to think of interactions between two parties, such as between a pathogen and a host, in terms of conflict, cooperation, co-evolution, conflicting and common interests, and trade-offs. Therefore, the ultimate approach explains why a disease occurs, or why it occurs a certain way, and although that information may bring some psychological comfort to a patient, it will not determine a course of treatment for any one individual patient. Ultimate explanations contribute to medicine by suggesting new avenues of research, which will eventually lead to new guidelines for treatment.

For example, let us take iron deficiency anaemia. Iron is an essential nutrient, most of which is used in haemoglobin, inside red blood cells. After an infection, the amount of available iron decreases. Traditionally, this was considered a consequence of infection and treated via iron supplements. However, if we consider that invading microorganisms (bacteria, fungi, protozoa) need iron to survive and reproduce, the same iron depletion can also be viewed as a defence by the host. A large body of work over the past few decades has shown that indeed iron depletion is a defence mechanism, and, hence, efforts to fight are counterproductive. Simply put, the optimum level of iron is different in the presence of pathogens and in the absence of pathogens. In the presence of pathogens, it is counterproductive to resist the decline in iron; the aim of a physician should to allow the body to find a new equilibrium point, as long as that new equilibrium does not cause permanent damage to the body. By the way, the exact same logic works for fevers: they are a defensive response that helps the host in fighting a pathogen, but if the response is too strong, it could cause permanent damage.

How can evolution produce defences that actually harm the body? First, there is always variability in a population. Just like some of us are tall and others are short, when attacked by pathogens some of us increase our temperature by one or two degrees, and others by 4 or 5 degrees. Second, the optimum response actually depends on the environment. In a sport arena or a battlefield, large size might be advantageous, but under conditions of severe food depletion, it becomes a liability. Similarly, a temperature increase of 1 or 2 degrees might be suitable to fight some pathogens, but not enough for others. Finally, we evolve to maximize our reproductive success, not to maximize our health. Pain and suffering, short life spans and even self-destructive behaviours could evolve if they lead to more offspring. Think of the surge in testosterone teenage boys and young men experience. It makes them very aggressive, highly competitive, and prone to take seemingly stupid risks (several TV programs are based on that premise). Stupid, until we realize that traditionally men established their place in society at about that age, and they needed to be competitive risk takers with aggressive tendencies.

I will close with one final example that illustrates the potential contributions of evolutionary thinking to medicine. Recently it had been suggested, and evidence is starting to accumulate, that a wide assortment of mental disorders can be lineally arranged, with schizophrenia at one end of the continuum and autism at the other, and result from a conflict between genes that come from the father and genes that come form the mother. In the right balance, they produce “normal” individuals, but when genes from one of the parents are expressed at the expense of genes from the other parent, a wide assortment of mental illnesses can develop. This evolutionary framework, which actually had its roots in the study of social insects (bees), has deep implications for the genetic basis of mental illness in humans.

On problem with “evolutionary medicine” is that, despite the impetus given by the Noble committee in 1974, the field is still mostly being led by evolutionary biologists with an interest in medicine. Evolution, although it is supposedly a unifying principle in biology, is usually taught in the 3rd or 4th year of a basic biology degree, and only one or two years of basic biology are required for entrance into most medical programs. Consequently, most medical students can obtain their degrees while remaining largely unaware of evolutionary principles and their relevance to medicine. Evolution is covered in very few medical programs, but until that becomes more common, maybe it is up to articles like this one to increase the level of awareness. To summarize, evolutionary biology offers a deeper understanding and integration that can benefit patients, physicians, and medical researchers.

Further reading

Ewald, P. W. 1994. Evolution of Infectious Disease. Oxford University Press.

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